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PTO/SB/05 (4/98)
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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	100.718.439
First Inventor or Application Identifier	David A. Cathey et al.
Title	LOW WORK FUNCTION EMITTERS AND METHOD FOR PRODUCTION OF FED'S
Express Mail Label No.	EL365623674US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231

1. [X] * Fee Transmittal Form *(e.g., PTO/SB/17)* *(Submit an original and a duplicate for fee processing)*
2. [X] Specification [Total Pages 13] *(preferred arrangement set forth below)*
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [X] Drawing(s) *(35 U.S.C. 113)* [Total Sheets 2] (Informal)
4. Oath or Declaration [Total Pages 2]
   a. [ ] Newly executed (original or copy)
   b. [X] Copy from a prior application (37 C.F.R. § 1.63(d)) *(for continuation/divisional with Box 16 completed)*
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

5. [ ] Microfiche Computer Program *(Appendix)*
6. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
   c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. [ ] Assignment Papers (cover sheet & document(s))
8. [ ] 37 C.F.R.§3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
9. [ ] English Translation Document *(if applicable)*
10. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
11. [X] Preliminary Amendment (First & Second)
12. [X] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
13. [ ] * Small Entity Statement(s) *(PTO/SB/09-12)* [ ] Statement filed in prior application, Status still proper and desired
14. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
15. [X] Other: One Sheet of Formal Drawings (Figs. 1-3)

16. **If a CONTINUING APPLICATION,** *check appropriate box, and supply the requisite information below and in a preliminary amendment:*

[ ] Continuation [X] Divisional [ ] Continuation-in-part (CIP) of prior application No: 09 / 105,613

Prior application information: Examiner Patel, A. Group / Art Unit: 2879

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. CORRESPONDENCE ADDRESS

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Signature		Date	1/21/00

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

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DATE OF DEPOSIT JANUARY 21, 2000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	David A. Cathey et al.
Serial No.:	To Be Assigned
Filed:	Herewith
For:	LOW WORK FUNCTION EMITTERS AND METHOD FOR PRODUCTION OF FED'S
Attorney Docket No.:	100.718.439

Box PATENT APPLICATION
Assistant Commissioner for Patents
Washington, DC 20231

TRANSMITTAL LETTER

Attached hereto for filing in the United States Patent Office under 37 C.F.R. § 1.53(b) are the following documents:

1. Utility Patent Application Transmittal, including;

   Photocopy of patent application filed June 26, 1998, comprising: 7 pages of Specification, 5 pages of Claims, 1 page of Abstract, and 2 sheets of Informal Drawings;

2. Photocopy of Combined Declaration and Power of Attorney;

3. First and Second Preliminary Amendment, including 1 Sheet of Formal Drawings (Figs. 1-3); and,

4. Fee Transmittal *(in duplicate)*.

Also enclosed is a self-addressed, postage prepaid postcard. Please return this postcard indicating the date of receipt by the U.S. Patent Office of the subject application for our files.

"Express Mail" Mailing Label No. EL365623674US
Date of Deposit: January 21, 2000

Please charge any fee deficiency or credit any overpayment in connection with this matter to Deposit Account No. 08-0219.

Respectfully submitted,

Date: January 21, 2000

James B. Lampert
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Attorney for Applicants

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	David A. Cathey et al.
Serial No.:	To Be Assigned
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Assistant Commissioner for Patents
Washington, DC 20231

FIRST PRELIMINARY AMENDMENT

Before calculating the filing fee and before examination, please amend the application as follows:

In the Specification:

Page 1, after line 6, please insert the following:

--Cross-reference to Related Application

This application is a divisional of serial no. 09/105,613, which is a divisional application of serial no. 08/543,819, now U.S. Patent No. 5,772,488, which is expressly incorporated by reference for all purposes.--

Page 4, line 2, delete "an".

Page 4, line 15, replace "$10^{21}/cm^3$" with --10^{21} atoms/cm^3--.

Page 5, line 10, replace "amorphos-silicon" with --amorphous silicon--.

"Express Mail" Mailing Label No. EL365623674US
Date of Deposit: January 21, 2000

Page 5, line 15, replace "then" with --than--.

Page 6, line 10, replace "ehtanol" with --ethanol--.

In the Claims:

Cancel claims 2-28.

SECOND PRELIMINARY AMENDMENT

After the filing fee has been calculated and after copendency has been established, please amend the application as follows:

In the claims:

Cancel claim 1.

Please add the following new claims:

29. A layered structure for use in manufacturing a cathode for a field emission display (FED) comprising a dielectric layer and a silicon layer formed over the dielectric layer, the silicon layer having an electropositive element diffused therein and extending down to an interface between the dielectric layer and the silicon layer.

30. The structure of claim 29, wherein the electropositive element is selected from the group consisting of H, Li, Be, B, Na, Cs, Mg, Al, Ga, Ba, Rb, Ca, K, Sr, and In.

31. The structure of claim 29, wherein the distribution of the electropositive element in the silicon layer is substantially even.

32. The structure of claim 29, wherein the structure is provided in a liquid solution including one of Na and Cs.

33. A field emission display comprising:

an anode;

a cathode;

the anode and the cathode sealed together and spaced apart to define an evacuated space therebetween;

a plurality of electron emitters located on the cathode, each of the emitters having tips for emitting electrons to the anode, the emitters being made of silicon and having an electropositive element both throughout a body of the emitters and at a surface of the emitters.

34. A display as in claim 33, wherein the distribution of the electropositive element in the body of the emitters is substantially even.

35. A display as in claim 33, wherein the electropositive element is chosen from Group IA of the periodic table.

36. A display as in claim 33, wherein the electropositive element comprises Cs.

37. A display as in claim 33, wherein the electropositive element is chosen from a group consisting of H, Li, Be, B, Na, Mg, Al, Ga, Ba, Rb, Ca, K, Sr, and In.

38. A display as in claim 33, wherein the electropositive element is chosen from Group IIA of the periodic table.

39. A display as in claim 33, wherein the electropositive element is chosen from Group IIIA of the periodic table.

40. A cathode for a display device comprising:

a substrate;

a plurality of electron emitters on the substrate and made from silicon, the emitters having a relatively wide base on the substrate and tapering to a tip away from the substrate; and

an electropositive element diffused in the emitters so that the electropositive element extends from the tip to the base, and wherein there is a significant amount of the electropositive element at the base.

41. A cathode as in claim 40, wherein the distribution of the electropositive element in the body of the emitters is substantially even.

42. A cathode as in claim 40, wherein the electropositive element is chosen from Group IA of the periodic table.

43. A cathode as in claim 40, wherein the electropositive element comprises Cs.

44. A cathode as in claim 40, wherein the electropositive element is chosen from a group consisting of H, Li, Be, B, Na, Mg, Al, Ga, Ba, Rb, Ca, K, Sr, and In.

45. A cathode as in claim 40, wherein the electropositive element is chosen from group IIA of the periodic table.

46. A cathode as in claim 40, wherein the electropositive element is chosen from group IIIA of the periodic table.

47. A cathode as in claim 40, the cathode further comprising an additional layer of silicon over the electron emitters to protect the electropositive element.

48. The cathode of claim 40, wherein the concentration of the electropositive element decreases from the tip to the base.

In the Drawings:

Please substitute the enclosed one sheet of formal drawings (Figs. 1-3) for those informal drawings filed herewith.

Remarks

Favorable examination is respectfully requested.

Respectfully submitted,

Dated: January 21, 2000

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Attorney for Applicants

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LOW WORK FUNCTION EMITTERS AND METHOD FOR PRODUCTION OF FED'S

GOVERNMENT RIGHTS

This invention was made with government support under Contract No. DABT 63-93-C0025 awarded by Advanced Research Projects Agency (ARPA). The government has certain rights in this invention.

BACKGROUND OF THE INVENTION

This invention relates to field emission displays, and more particularly to the formation of low work function emitters.

The required turn-on voltage for an emitter at a constant current is a function of the work function of the material at the surface of the emitter. For example, see U.S. Patent No. 4,325,000, issued April 13, 1982, incorporated herein by reference, and Michaelson, H.B. "Relation Between An Atomic Electronegativity Scale and the Work Function," 22 IBM Res. Develop., No. 1, Jan. 1978. Reduction of the work function of a material can be achieved by coating the surface with an electropositive element. For example, see U.S. Patent No. 5,089,292, incorporated herein by reference. However, such knowledge has never been translated into a useful field emission display. Electropositive materials are very reactive, and, therefore, upon coating on an emitter, they quickly begin to react with most atmospheres, resulting in a high work function material coating the emitter. Accordingly emitters coated with low work function materials on the surface have traditionally not been useful. Also, the compositions in which electropositive elements normally exist (for example, as a salt with Cl) include elements that have a very large work function (e.g. Cl).

The present invention provides solutions to the above problems.

SUMMARY OF THE INVENTION

According to one aspect of the invention, a field emission display is provided comprising: an anode; a phosphor located on the anode; a cathode; an evacuated space between the anode and the cathode; an emitter located on the cathode opposite the phosphor; wherein the emitter comprises an electropositive element both in a body of the emitter and on a surface of the emitter.

According to another aspect of the invention a process for manufacturing an FED is provided comprising the steps of: forming an emitter comprising an electropositive element in the body of the tip; positioning the emitter in opposing relation to a phosphor display screen; creating an evacuated space between the emitter tip and the phosphor display screen; and causing the electropositive element to migrate to the an emission surface of the emitter.

DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and for further advantages thereof, reference is made to the following Detailed Description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a side view of an embodiment of the present invention.

Fig. 2 is a side view of a detailed area of Fig. 1.

Fig. 3 is a side view of an alternative embodiment to the embodiment of the invention seen in Fig. 1.

It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

DETAILED DESCRIPTION

Referring now to Fig. 1, a field emission display 1 according to the present invention is shown comprising: an anode 10, which in this embodiment comprises a faceplate, or screen of the field emission display. This embodiment further comprises a phosphor screen 12, located on the anode 10; a cathode 14, attached to anode 10 by glass frit 15; and an evacuated space 16 between the anode 10 and the cathode 14.

Referring now to Fig. 2, a more detailed view of cathode 14 in the region of circle A of Fig. 1 is seen comprising: an emitter tip 18 located on the cathode 14 opposite the phosphor screen 12. In this embodiment of the invention, the emitter tip 18 comprises an electropositive element 20 both in a body 18a of the emitter tip 18 and on a surface 18b of the emitter tip 18. Spaced from emitter tip 18 by dielectric 19 is grid electrode 17. In this embodiment, the distribution of the electropositive element 20 in the body 18a of the emitter tip 18 is substantially even. However, according to an alternative embodiment, the distribution is more uneven, wherein there is a gradient of the electropositive element 20 in the body 18a and the surface 18b is substantially all electropositive element 20. According to one specific embodiment, the distribution is an exponential change, and the electropositive element is provided in the body 18a such that the work function of the surface 18b of emitter tip 18 is reduced by at least 50 %. For example, in the case of an amorphous silicon emitter tip, the work function is 3.9 eV without an electropositive component, and about 2.0 eV if Na is doped according to the dip process described below.

Acceptable specific elements for electropositive element 20 are chosen from groups IA, IIA, and IIIA of the periodic table. One specific element known to be useful as electropositive element 20 comprises Cs. Another element known to be useful comprises Na. Others known or believed to be useful comprise: H, Li, Be, B, Mg, Al, Ga, Ba, Rb, Ca, K, Sr, and In.

An example process for manufacturing a field emission display ("FED") according to the present invention comprises the steps of: forming an emitter tip 18 comprising an electropositive element 20 in the body 18a of the emitter tip 18; positioning the emitter tip 18 in opposing relation to a phosphor screen 12 on the display; creating an evacuated space 16 between the

emitter tip 18 and the phosphor screen 12; causing the electropositive element 20 to migrate to the an emission surface 18b of the emitter tip 18, whereby the display of Fig. 2 results.

According to an example process of forming the emitter tip as in Fig. 2, the emitter tip 18 is formed by methods that will be understood by those of skill in the art (for example, see U.S. Patent Nos. 4,940,916; 5,391,259; and 5,229,331, all of which are incorporated herein by reference), and the substrate with the emitter tip 18 is contacted with a solution in a glass container. The solution comprises an electropositive element as the solute, and a solvent (for example, alcohol). Other solvents believed to be useful according to other embodiments of the invention include: water, acetone, or any other solvent capable of dissolving electropositive salts.

As mentioned above, said electropositive element comprises an element chosen from groups IA, IIA, and IIIA of the periodic table. One specific element known to be useful as electropositive element comprises Cs. Others known or believed to be useful comprise: H, Li, Be, B, Na, Mg, Al, Ga, Ba, Rb, Ca, K, Sr, and In.

According to one example of the present invention, the contacting comprises dipping the emitter tip into the solution for a time sufficient to cause $10^{21}/cm^3$ of electropositive material to penetrate into the emitter tip. Some acceptable solutions, dip times, and dip temperatures are listed below (other examples will occur to those of skill in the art):

Solution Composition	Dip Time	Dip Temperature (Degrees C)
propan-1-ol solvent - NaCl solute	15 minutes	82
methanol solvent - CsCl solute	15 minutes	62
ethanol solvent - NaCl solute	15 minutes	75
methanol solvent NaCl solute	15 minutes	62
propan-1-ol solvent - CsCl solute	15 minutes	82
ehtanol solvent - CsCl solute	15 minutes	75

In a more specific embodiment, a silicon substrate from which the emitters have been

shaped is dipped in a solution of propan-2-ol, as the solvent, and CsCl, the solution being kept just under the boiling temperature. Next, either amorphous silicon (a-Si) or micro crystalline silicon (u-Si) is deposited at between about 200 degrees C and about 300 degrees C (for example, by plasma-enchanced chemical vapor deposition). Thus, the Cs layer is protected from reaction with other elements by the silicon deposition during further handling. Once the display is ready for assembly, the various components of Fig. 1 are brought together in a vacuum, and then sealed and heated. Since in a-Si and u-Si the density of surface states is high, most of the Cs atoms will migrate to the surface of emitter tip 18 and be trapped right at the surface of the deposited films, where a cesium rich monolayer 20a is created.

In another specific embodiment, a glass substrate with 7000 angstrom amorphos-silicon emitters formed thereon was dipped in a solution of propan-1-ol, as the solvent, and NaCl for 15 minutes at a temperature just below boiling. The result was an approximately 7000 angstrom alpha-silicon/glass structure with Na doped therein. SIMS analysis of H, P, and Na were conducted comparing a similar sample which had not been dipped. The NaCl dipped structure had about 500 times higher Na near the Si surface (at about 500 angstroms depth) then the sample which had not been dipped. The Na level remained higher throughout the 7000 angstroms tested, but decreased to about 80 times higher near the Si/glass interface (at about 6000 angstroms). Further, the dipped sample included a slightly higher P than the undipped sample, but the difference was less than about 1.5 times. No H difference was seen between the samples. Mo contamination (due to use of a furnace having therein) was detected on the NaCl dipped sample, but no Mo was seen in the undipped sample. Mo contamination is avoided in other embodiments. Higher K and Ca were also observed in the NaCl dipped sample. Surprisingly, Cl was not detected in either the dipped or undipped sample. This is an important finding as Cl has a high work function and is undesirable in the emitter tip.

According to still a further embodiment, the emitter tip is made after the substrate from which the emitter tip is formed is doped with an electropositive element. For example, according to one alternative embodiment of the invention, the substrate on which the emitter tip is manufactured is dipped, before the formation of the emitter tip, and the emitter tip is then formed

on the substrate. According to specific examples of processes believed to be acceptable according to this embodiment, the following parameters are used:

Solution Composition	Dip Time	Dip Temperature (Degrees C)
propan-1-ol solvent - NaCl solute	15 minutes	82
methanol solvent - CsCl solute	15 minutes	62
ethanol solvent - NaCl solute	15 minutes	75
methanol solvent NaCl solute	15 minutes	62
propan-1-ol solvent - CsCl solute	15 minutes	82
ehtanol solvent - CsCl solute	15 minutes	75

According to still a further embodiment, plasma-enhanced chemical vapor deposition is used to place the electropositive element in the body of the emitter tip. As before, the vapor deposition is conducted either before or after the formation of the emitter tip. After the vapor deposition, heating will cause diffusion of the electropositive element into the body of the emitter tip. After assembly in an evacuated space, subsequent heating causes the material to migrate to the surface of the emitter tip, where it will not react due to the vacuum, and a low work function emitter tip is thereby achieved.

Another acceptable method of placement of the electropositive element in the body of the emitter tip is through ion-implantation, again followed by heating after evacuation to cause diffusion.

In embodiments in which the electropositive element is applied before the emitter tip is formed, some of the electropositive element will be exposed during subsequent steps, such as etching. When this occurs, an oxide or non-volatile salt will form, depending upon the atmosphere at the surface of the emitter tip when exposure occurs. In these embodiments, the oxide or non-volatile salt which is rinsed (for example, with buffered oxide etchant in the case of

oxide or water in the case of salt), before further processing. Acceptable examples of materials for the substrate which is doped with the electropositive element include, for example, Si, Mo, Cr, and W. Others will occur to those of skill in the art.

Other steps to form the emitter tip and other structures of the FED will be understood by those of skill in the art and require no further explanation here.

According to some embodiments (for example, see Fig. 3), the display is sealed by glass frit seal 33, chosen to match the thermal expansion characteristic of the cathode 35, which, in this embodiment, comprises a glass substrate 37 on which emitters 39 are formed. This embodiment is particularly useful for large area displays. The sealing is done in a vacuum space by heating the entire device. The heating to a seal temperature for the frit 33 (for example, 450 degrees C for a lead-glass-based frit), causes the migration of the electropositive element to the surface of the emitters 39.

According to still a further embodiment, seen in Fig. 1, the cathode 14 is encased by a backplate 50, which is also sealed in vacuum by a frit 51 by heating. This embodiment is useful in small area displays where, for example, the cathode 14 comprises a silicon substrate onto which the emitters 18 are formed. Here, the cathode 14 is attached to faceplate 10 by another frit seal 15, also sealed by heating.

What is claimed is:

1. A field emission display comprising:

an anode;

a phosphor located on the anode;

a cathode;

an evacuated space between the anode and the cathode;

an emitter located on the cathode opposite the phosphor;

wherein the emitter comprises an electropositive element both in a body of the emitter and on a surface of the emitter.

2. A display as in claim 1 wherein the distribution of the electropositive element in the body of the emitter is substantially even.

3. A display as in claim 2 wherein the electropositive element comprises and element chosen from group IA of the periodic table.

4. A display as in claim 3 wherein the electropositive element comprises Cs.

5. A display as in claim 2 wherein the electropositive element chosen from a group consisting of H, Li, Be, B, Na, Mg, Al, Ga, Ba, Rb, Ca, K, Sr, and In.

6. A display as in claim 2 wherein the electropositive element is chosen from group IIA of the periodic table.

7. A display as in claim 2 wherein the electropositive element is chosen from group IIIA of the periodic table.

8. A process for manufacturing an FED comprising the steps of:

forming an emitter comprising an electropositive element in the body of the tip;

positioning the emitter in opposing relation to a phosphor display screen;

creating an evacuated space between the emitter tip and the phosphor display screen;

causing the electropositive element to migrate to the an emission surface of the emitter.

9. A process as in claim 8 wherein said forming comprises:

forming an emitter;

contacting the emitter with a solution, the solution comprising an electropositive element as the

solute.

10. A process as in claim 9 wherein said solution comprises an alcohol solvent.

11. A process as in claim 10 wherein said electropositive element comprises an element chosen from group IA of the periodic table.

12. A process as in claim 11 wherein the electropositive element comprises Cs.

13. A process as in claim 10 wherein the electropositive element is chosen from a group consisting of H, Li, Be, B, Na, Mg, Al, Ga, Ba, Rb, Ca, K, Sr, and In.

14. A process as in claim 10 wherein the electropositive element is chosen from group IIA of the periodic table.

15. A process as in claim 10 wherein the electropositive element is chosen from group IIIA of the periodic table.

16. A process as in claim 9 wherein said contacting comprises dipping the emitter into the solution for a time sufficient to cause doping of $10^{21}/cm^3$ of electropositive material to penetrate into the emitter.

17. A process as in claim 16 wherein said solution comprises propan-1-ol as the solvent and NaCl as the solute.

18. A process as in claim 17 wherein said solution is at a temperature below the boiling point of the solvent and said contacting continues for about 15 minutes.

20. A process as in claim 16 wherein said solution comprises methanol as the solvent and CsCl as the solute.

21. A process as in claim 17 wherein said solution is at a temperature below the boiling point of the solvent and said contacting continues for about 15 minutes.

22. A process as in claim 8 wherein said forming comprises:
forming an emitter from a substrate comprising electropositive material, wherein the emitter formation causes electropositive material to be exposed and react at the surface of the emitter; and
removing reacted electropositive material.

23. A process as in clam 22 wherein exposed electropositive material forms an oxide and said removing comprises washing with a buffered oxide etch.

24. A process as in claim 22 wherein exposed electropositive material forms a salt and said

removing comprises washing with water.

25. A process as in claim 8 wherein said forming comprises:

forming an emitter;

vapor deposition of an electropositive element in on the emitter;

heating the emitter to cause the electropositive element to penetrate into the body of the emitter.

26. A process as in claim 25 further comprising removal of unpenetrated electropositive material from the surface of the emitter.

27. A process as in claim 8 wherein said forming comprises:

forming an emitter;

ion implantation of an electropositive element in on the emitter.

28. A process as in claim 8 wherein said causing the electropositive element to migrate to the an emission surface of the emitter comprises heating the display after the space is evacuated, wherein the electropositive element migrates to the surface creating a low work function for the emitter.

ABSTRACT

According to one aspect of the invention, a field emission display is provided comprising: an anode; a phosphor screen located on the anode; a cathode; an evacuated space between the anode and the cathode; an emitter located on the cathode opposite the phosphor; wherein the emitter comprises an electropositive element both in a body of the emitter and on a surface of the emitter. According to another aspect of the invention a process for manufacturing an FED is provided comprising the steps of: forming an emitter comprising an electropositive element in the body of the tip; positioning the emitter in opposing relation to a phosphor display screen; creating an evacuated space between the emitter tip and the phosphor display screen; and causing the electropositive element to migrate to the an emission surface of the emitter.

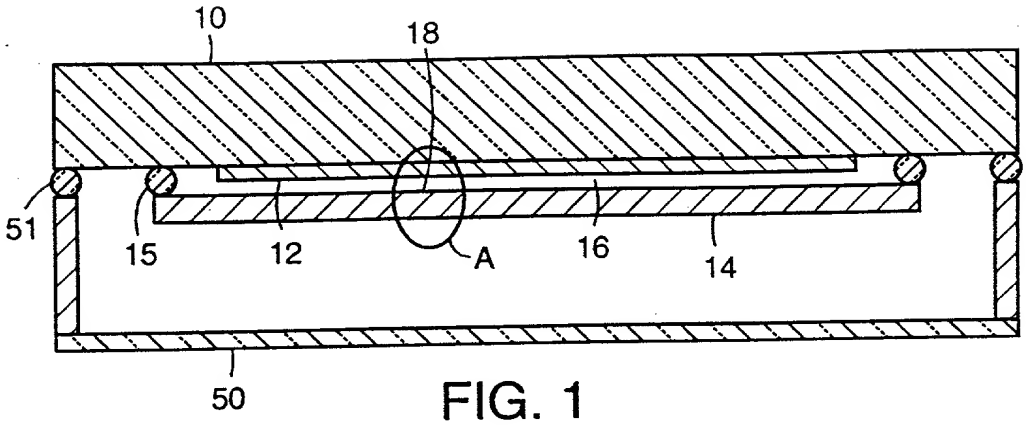

FIG. 1

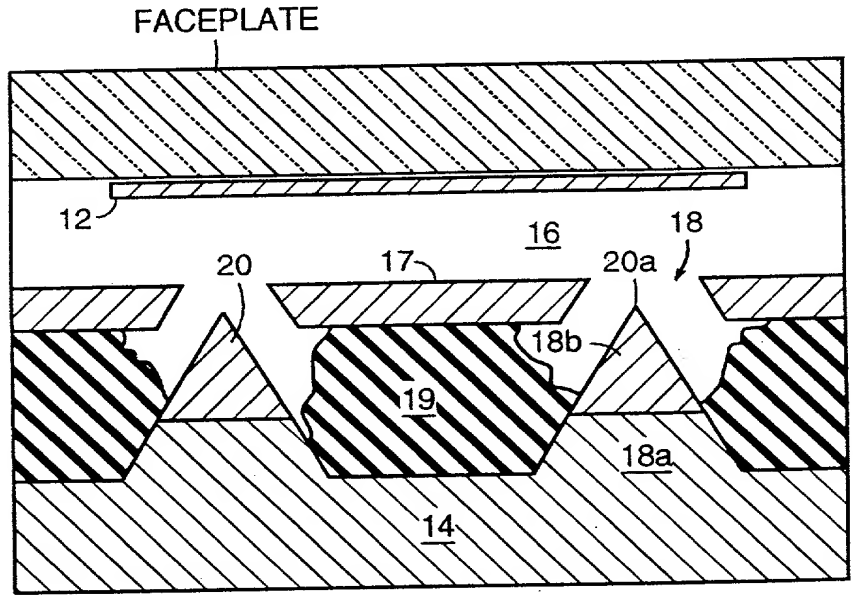

FIG. 2

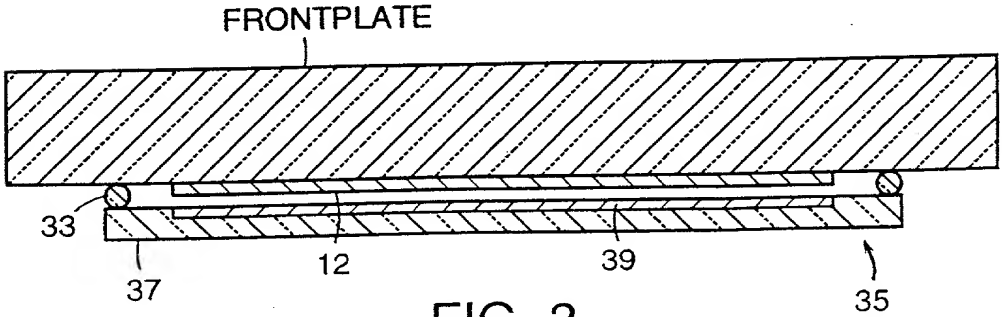

FIG. 3

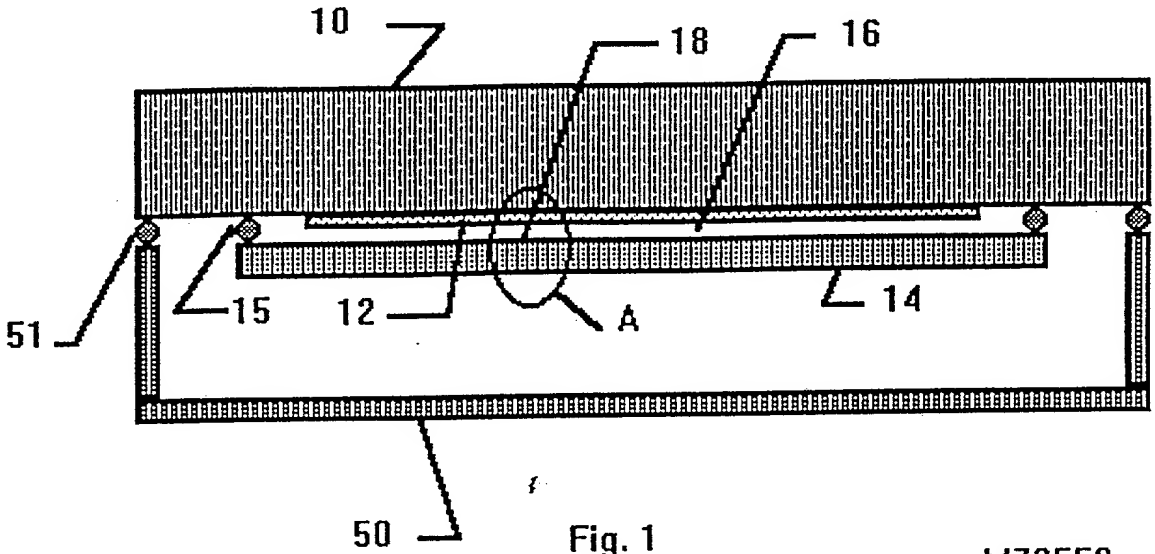

Fig. 1

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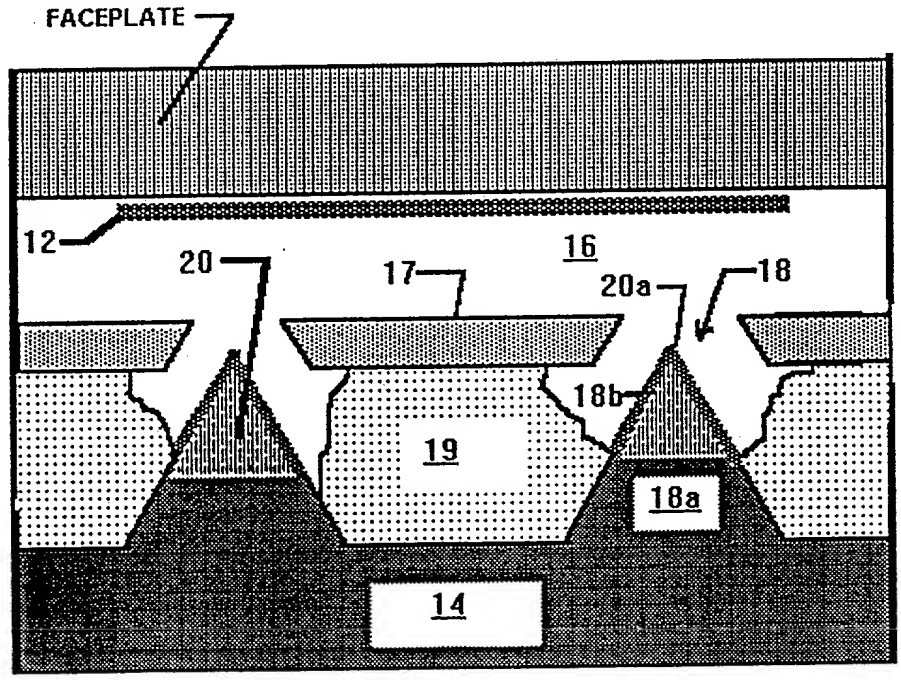

Fig. 2

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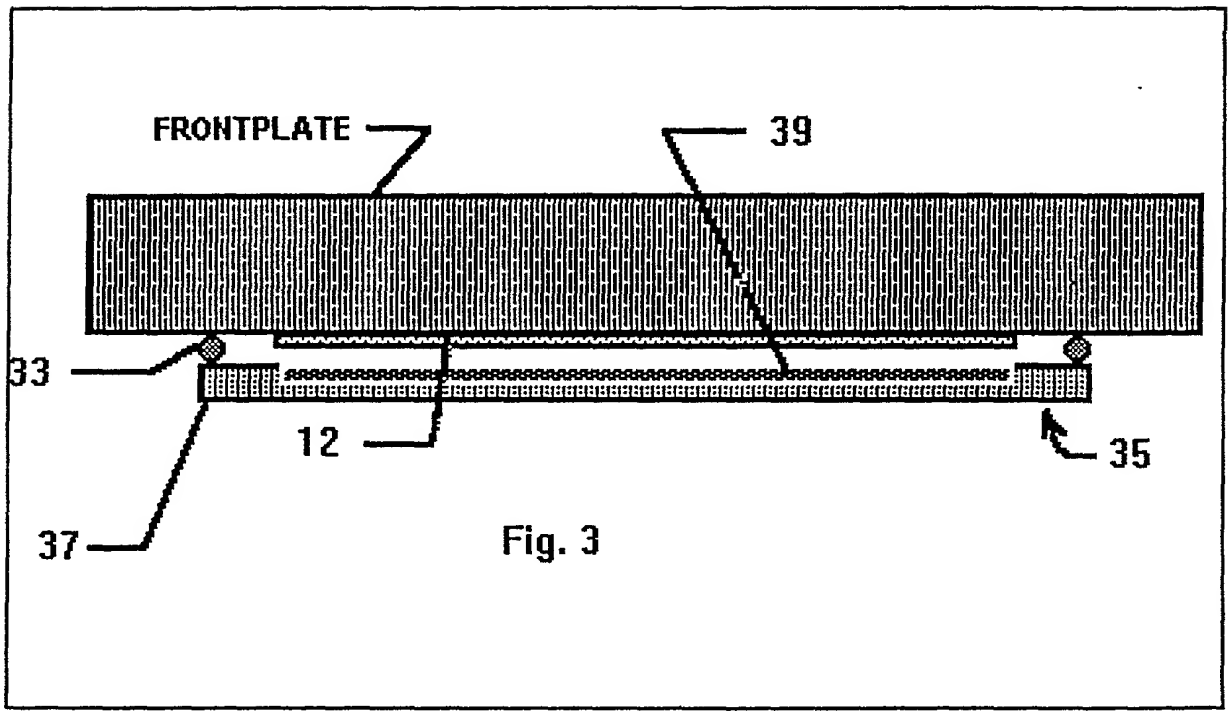

Fig. 3

COMBINED DECLARATION AND POWER OF ATTORNEY

As the below named inventors, We hereby declare that:

Our residence, post office address and citizenship are as stated below next to our name.

We believe we are the original, first and sole inventors of the subject matter which is claimed and for which a patent is sought on the invention entitled

"LOW WORK FUNCTION EMITTERS AND METHOD FOR PRODUCTION OF FED'S"

specification attached hereto.

We hereby state that we have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

We acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations §1.56(a).

We hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s):

Number	Country	Date Filed

We hereby appoint the following attorney(s) and/or agent(s): Gordon T. Arnold, Reg. No. 32,395 and Bruce W. Slayden II, Reg. No. 33,790, Matthew G. Reeves, Reg. No. 39,339, of the firm of Bardehle, Pagenberg, Dost, Altenburg, Frohwitter, Geissler, and Partners, Three Riverway, Suite 550, Houston, Texas 77056, telephone number (713) 621-0703, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

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DATE OF DEPOSIT JANUARY 21, 2000

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